REMARKS

By the present amendment, claims 1, 30 and 34 are pending in the application.

Restriction Requirement

In response to the restriction requirement, non-elected claims 2 to 29, 31, 32 and 35 to 46 have been canceled by the present amendment without prejudice to the filing of a divisional patent application(s) directed to the non-elected claims.

Claim Amendments

The preamble of claim 1 has been amended so that claim 1 is expressly directed to a "computer based system".

Claim 1 has also been amended to recite the "production simulator", the "mathematical expression model holding device" and the "optimization calculation device" as means plus function claim elements.

Elected claim 33 has been canceled.

Specification

The specification has been amended at page 91 to correct a typographical type error.

Abstract

In response to the objection of the Office Action, the Abstract of the Disclosure has been amended to change "crated" to read --created--.

In view of the present amendment, it is respectfully requested that the objection to the Abstract of the Disclosure be withdrawn.

§101

Claim 1

Claim 1 was rejected under 35 U.S.C. §101 on the grounds that the claimed invention is directed to non-statutory subject matter. The Office Action maintained that the elements of claim 1 could be reasonably interpreted by one skilled in the art to be software.

In response to this rejection, claim 1 has been amended by the present amendment.

The preamble of claim 1 has been amended so that claim 1 is expressly directed to a "computer based system". Therefore, it is clear to one of ordinary skill in the art that amended claim 1 is directed to hardware.

Claim 1 has also been amended to recite "a production simulator means for simulating"; "a mathematical expression model holding means for holding"; and "an optimization calculation means for performing".

35 U.S.C. §112, last paragraph, specifically provides for means plus function clauses and as provided for in 35 U.S.C. §112, last paragraph, the means shall be "construed to cover the corresponding structure, material or acts described in the specification or equivalents thereof".

Thus by statute, the means of the amended claim 1 are construed as "structure, material or acts" and therefore could not possibly be construed or interpreted by one of ordinary skill in the art as software.

In view of the present amendment, it is respectfully requested that the rejection of claim 1 under 35 U.S.C. §101 be withdrawn.

Claim 33

Claim 33 was rejected under 35 U.S.C. §101 on the grounds that the claimed invention is directed to non-statutory subject matter.

By the present amendment, claim 33 has been canceled.

Therefore, the rejection of claim 33 under 35 U.S.C. §101 is now moot.

§102

Claims 1, 30, 33 and 34 were rejected under 35 U.S.C. §102(b) as being anticipated by Japan No. 2002-229635 to Kobayashi.

Claims 1, 30, 33 and 34 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,216,593 to Dietrich et al.

Claims 1, 30, 33 and 34 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,606,527 to de Andrade, Jr. et al.

These rejections are respectfully traversed.

The Present Invention

Technical Field Of The Present Invention

The present invention relates to a manufacturing/distribution schedule creation apparatus and method, and a computer-readable recording media which stores computer programs, and particularly relates to those favorable for use in the case where a schedule of a target system is accurately created without depending on the level of skill of the operator.

Structure Of The Present Invention

The present invention includes, when explained in reference to Fig. 1, a distribution simulator 100, a mathematical expression model 110, an optimization calculation device 120, an evaluation function S and the like.

The production simulator means 100 is a simulator which simulates a plant. It is configured as a discrete system that moves a thing at each event (event of the simulator).

A distribution model (mathematical expression model 110) is configured to correspond to the production simulator means 100. The mathematical expression model holding means 110 is created by acquiring elements (all the distribution states and distribution constraints may be included or only part of them may be included) relating to the distribution schedule to be created from a distribution state (in-process product, inventories, process step, equipment, state of operation of cranes or AGV, and the like) and a distribution constraint (processing order, processing time, priority, item to be prohibited and the like) of a manufacturing/distribution process and is held by a mathematical model holding means.

The optimization calculation means 120 performs optimization calculation (linear programming, mixed integer programming, mathematical programming or the like) using the mathematical expression model 110 and the evaluation function S, and the calculation result is inputted to the production simulator means 100 as a distribution instruction for the production simulator means 100. The evaluation function S mathematically expresses items to be evaluated (inventory amount, involved cost, or the like) in a form meeting with the method of optimization calculation.

The present invention links the structural elements such as the production simulator means 100, the mathematical expression model means 110, the optimization calculation means 120, the evaluation function S to each other as follows.

1). An initial state at the time of starting the schedule creation is set to the production simulator means 100. The initial state includes a period of creating the schedule, the starting time, distribution state (charging, in-process product, inventory, operation state of equipment and the like).

2). Simulation with the production simulator means 100 is started. The production simulator means 100 creates the mathematical expression model 110 by acquiring elements (all the distribution states and distribution constraints may be included or only part of them may be included) relating to the distribution schedule to be created, and the mathematical expression model is held by the mathematical expression model holding means 110.

3). The optimization calculation means 120 performs optimization calculation (linear programming, mixed integer programming, mathematical programming, or the like are used), using the mathematical expression model and the evaluation function S.

4). The optimization calculation means 120 inputs the calculation result to the production simulator means 100 as a distribution instruction for the production simulator means 100.

5). A time management part 101 in the production simulator means 100 advances the event a step further according to distribution instructions.

6). Taking a state that the event is advances a step further as a starting state of next link processing, the production simulator means 100 acquires elements relating to a distribution schedule to be created and creates the second mathematical expression model, and the second mathematical expression model is held by the mathematical expression model holding means 110.

7). The optimization calculation means 120 performs the second optimization calculation using the second mathematical expression model and the evaluation function S.

8). The optimization calculation means 120 inputs the second calculation result to the production simulator means 100 as a distribution instruction for the production simulator means 100.

9). The time management part 101 in the production simulator means 100 advances the event a step according to the second distribution instruction.

These steps are repeated so much as a schedule creation time period (the number of occurrence times of the event that requires judgment). By this linking operation (repeating of the above-described processing (1) to (9)), it is possible to obtain a production simulation result at a high speed by performing only one time of simulation without performing the simulation plural times repeatedly. The result realizes a schedule executable making a desired evaluation index optimal for large-scale manufacturing/distribution process under complicated distribution constraint conditions.

The present invention is not to execute simulation based on a conventional prescribed rule, but to execute simulation based on the result (distribution instruction) of optimization calculation for every event. Thus, it is possible to securely obtain a theoretical and optimal schedule by performing only one simulation.

Object Of The Present Invention

The conventional manufacturing/distribution schedule is created manually based on past experiences by a person skilled in the art. The creation of the manufacturing/distribution schedule is as follows. A simulator that simulates an object (plant or the like) is created, a series of the following processes such as determining conditions, executing the simulation, and evaluating the result, is repeated many times while variously changing the conditions until the satisfactory result is obtained. Furthermore, using a method of which optimality is assured, such as linear programming, mathematical programming, or the like, a conventional manufacturing distribution schedule is created taking a calculation time longer than a practically allowable period of time for a practical scale (generally a problem scale is large).

Still another conventional method of creation of a manufacturing/distribution schedule in which practical constraints and conditions are calculated without being expressed in a mathematical expression usable in linear programming, mathematical programming, or the like, which leads to creation of a manufacturing/distribution schedule for which practical constraints and conditions are not satisfied.

In contrast, in the present invention,

(i) the schedule is created (or processes are controlled) by linking the optimization calculation using a mathematical model for a large-scale and complicated manufacturing/distribution process which is a target for the schedule to be created (or to control processes) and a detailed simulation for the manufacturing/distribution process.

(ii) Moreover, by the above-described linking, the present invention enables obtaining the optimal manufacturing/distribution simulation result at a high speed by performing only one simulation without repeating the simulation many times.

(iii) Furthermore, since a detailed simulator acquiring complicated practical constraints and conditions in a large-scale manufacturing/distribution process which is a target for schedule creation is used, a manufacturing/distribution schedule assured to be usable in an actual manufacturing/distribution schedule can be created at a high speed with high accuracy by the present invention.

(iv) In addition, the schedule is created in the present invention by linking the optimization calculation using a mathematical model and the detailed simulation of a manufacturing/distribution process, using items to be evaluated in advance (inventory amount, involved cost, or the like) as an evaluation function of the optimization calculation, so that an optimal schedule for the items to be evaluated in advance (inventory amount, involve cost, or the like) can be created.

By operating as above, it is possible, in accordance with the present invention, to create a schedule optimizing an executable and desirable evaluation index in a short period (within a practical period of time) even for a large-scale manufacturing/distribution process with complicated distribution constraints and conditions.

Effect Of The Present Invention

As described in the above, the conventional methods have the following problems such that (a) the creation of a schedule has to be made by only experienced experts, yet it is inefficient, easily creates mistakes due to a manual work, and takes a lot of time for rescheduling at the time of trouble, (b) when a simulator is used, conditions have to be variously changed while evaluating the result, repeating them many times, and it takes a lot of time irrespective of insufficient accuracy, (c) a practical-scale (usually the problem scale is large) manufacturing/distribution schedule is created using linear programming, mathematical programming, or the like, taking a calculation time longer than a practically allowable period of time, or the manufacturing/distribution schedule is created in which practical constraints and conditions are calculated without being expressed in a mathematical expression usable in linear programming, mathematical programming, or the like, which leads to creation of a manufacturing/distribution schedule in which the practical constraints and conditions are not satisfied.

The present invention is a method to create a schedule (or control processes) by linking the manufacturing/distribution simulator and the optimization calculation, and since it is possible to obtain the schedule complying with the distribution constraints included in the optimization calculation or the simulator, its executability in an actual manufacturing process is assured.

Accordingly the present invention has a breakthrough effect enabling the creation of a schedule (or control processes) optimally satisfying the evaluation index designated in the optimization calculation within the executable extent. For instance, by performing only one simulation (without repeating the simulation a plurality of times while changing the conditions), the optimal manufacturing/distribution schedule result can be obtained without repeating the simulation a plurality of times while changing the conditions and without repeating the evaluation of the results many times. Therefore, a manufacturing/distribution schedule in a large-scale plant can be created in a short time.

In addition, since the schedule complying with the distribution constraints included in the simulator that simulates the manufacturing/distribution process in detail is obtained, the manufacturing/distribution schedule is assured to be actually usable in a manufacturing/distribution process being the target for the schedule which can be created at a high speed with high accuracy.

Further, by determining a mathematically optimal distribution instruction by combining (1) simulator, (2) mathematical model, (3) optimization calculation, and (4) evaluation function without establishing a detailed simulation rule, it enables performing maintenance by creating a simulator or modifying instrument in a short time. In addition, for the case of using only a method assuring the optimality such as mathematical programming, the schedule, in accordance with the present invention, can be created in a practical period of time for larger-scale problems, and it is possible to solve errors caused by constraints or conditions unable to be described with mathematical expressions by linking with simulators so that the schedule assuring executability can be created.

Furthermore, it is possible to create a manufacturing schedule having a high simulation accuracy, the ability to perform in a short calculation time, and considering

optimality by dynamically exchanging the necessary and sufficient information between the simulator means, the mathematical model holding means and the optimization calculation means during performing the simulation.

COMPARISON BETWEEN THE PRESENT INVENTION AND THE TECHNOLOGY DESCRIBED IN THE CITED REFERENCES

As will be described below, none of the cited references disclose or suggest using a simulator and there is absolutely no disclosure or suggestion of a configuration linking a simulator and optimization calculation as in the present invention.

Japan No. 2002-229635 ("JP ' 635")

The technology disclosed in JP '635 includes a detector detecting a group of products to be manufactured or transferred; an optimization means determining the optimal solution using an evaluation function by establishing a prescribed mathematical model for combination of possible candidates for selecting a process course; and a means determining equipment, course, time, and the like from the obtained optimal solution. However, JP '635 is a configuration having an optimization means only, and no simulator.

U.S. Patent No. 5,216,593 ("US '593")

The technology disclosed in US '593 belongs to the technical field of distributing sources such as capital, products (inventory), human resources, materials, operating time, equipments, etc. and discloses a configuration to which the optimization function is added, but US '593 is not provided with a simulator.

U.S. Patent No. 6,606,527 ("US '527")

The technology disclosed in US '527 belongs to the technical field of production management and creation of a manufacturing plan of a plant, and discloses a configuration to which the optimization function is added, but US '527 is not provided with a simulator.

As described above, in the cited references, there is absolutely no disclosure or suggestion of linking an optimization calculation device and a production (manufacturing/distribution) simulator as in the present invention in which a distribution instruction created with an optimization calculation means is executed with a production (manufacturing/distribution) simulator means, the production (manufacturing/distribution) simulator means outputs the instruction to execute optimization calculation to the optimization calculation means for a new event, and the production (manufacturing/distribution) simulator means and the optimization calculation means are linked together, so that the manufacturing/distribution schedule is created by repeating these procedures for every event.

When compared with the technology described in cited references, the present invention can obtain a unique effect such that it can determine a solution to a problem in a large scale process in a practical period of time, compared with a case of using only a method such as mathematical programming. The present invention is a configuration combining (1) simulator, (2) mathematical expression model, (3) optimization calculation, and (4) evaluation function, and it is possible, by the present invention, to solve errors caused by constraints or conditions which cannot be described with mathematical expressions by linking with a simulator so that a schedule for which executability is assured can be created.

As described above, the present invention differs from the technology described in JP '635, US '593 or US '527 in its configuration, operation and effect.

It is therefore submitted that claims 1, 30 and 34 are patentable over JP '635, US '593 and/or US '527 standing alone or in combination.

CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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